Influence of Acceptor Doping of $SrTiO_3$ on Ionic and Electronic Conductivity

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INTRODUCTION

$SrTiO_3$-based oxides with perovskite structure show mixed ionic-electronic conductivity (1) that make it possible to use them as high temperature superconductors, catalysts, electrode materials for high temperature solid oxide fuel cells and other electrochemical devices, membranes for oxygen separation and hydrogen production, etc. Doping of strontium titanate with different impurities allows to vary ionic and electronic structure and therefore electrical properties of these compounds in a wide range. In this work, an influence of Ti substitution by Fe and Mn on ionic and electronic conductivity of strontium titanate has been studied.

EXPERIMENTAL

The systems $SrTi_{1-x}Fe_xO_{3-\delta}$ and $SrTi_{1-x}Mn_xO_{3-\delta}$ (x = 0 – 0.5)) were synthesized via a solid state reaction. X-ray diffraction showed that $SrTi_{1-x}Fe_xO_{3-\delta}$ -samples were single-phase and exhibited cubic symmetry. As to $SrTi_{1-x}Mn_xO_{3-\delta}$ - system, the sample of composition x = 0.1 was single-phase with a cubic structure, while the rest of the samples showed a mixture of at least two phases. The density of the samples was no less than 93% of theoretical one.

The electrical properties of $SrTi_{1-x}M_xO_{3-\delta}$ (M = Fe, Mn) have been studied in a wide region of the oxygen partial pressures ($P(O_2)$) at high temperatures by means of dc four-probe technique. To measure the electrical conductivity at different $P(O_2)$ the sample was set in an one-end-closed tube, made from ZrO_2-based electrolyte. The oxygen activity in the tube was monitored by the oxygen pump and controlled by the oxygen sensor.

RESULTS AND DISCUSSION

The behavior of the isotherms of electrical conductivity σ on $P(O_2)$, obtained at 900 and 1000°C, shows electron and hole conductivity at low and high $P(O_2)$, respectively, and predominantly ionic conductivity in a wide region of intermediate $P(O_2)$ (Fig.1). Substitution of Ti by Fe and Mn results in an increase of ionic conductivity. The doped samples show a sharp decrease of conductivity in the $P(O_2)$ region between 10^{-3} and 10^{-4} atm, where the conductivity is supposed to be predominantly n-type electronic. Temperature decrease leads to a shift of the conductivity drop to lower $P(O_2)$. The conductivity drop observed can be induced by the change of degree of oxidation of the impurities.

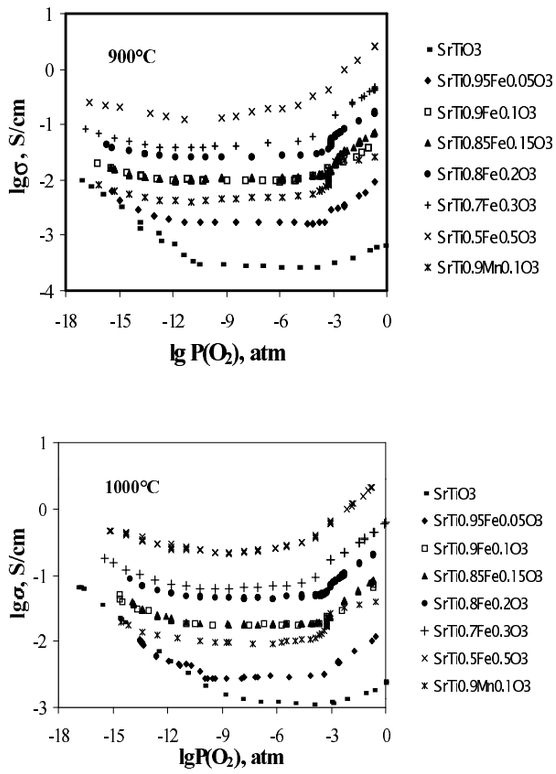

Fig.1. Dependencies of electrical conductivity of $SrTi_{1-x}M_xO_{3-\delta}$ (M = Fe, Mn) on $P(O_2)$ at 900 and 1000°C.

REFERENCES

1. S.Steinsvik et al., J.Phys.Chem.Solids, **58**, 969 (1997).